United States Patent [19]

Ohnishi et al.

[11] **4,366,491**

[45] **Dec. 28, 1982**

[54] **ELECTROGRAPHIC IMAGING SYSTEM**

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[21] Appl. No.: **81,488**

[22] Filed: **Oct. 3, 1979**

[30] **Foreign Application Priority Data**

Nov. 21, 1978 [JP] Japan 53-144495
Dec. 29, 1978 [JP] Japan 53-161620

[51] **Int. Cl.**^{3} **G03G 15/44**

[52] **U.S. Cl.** **346/155**; 101/DIG. 13; 346/153.1

[58] **Field of Search** 346/155, 74.1, 154, 346/153; 101/DIG. 13

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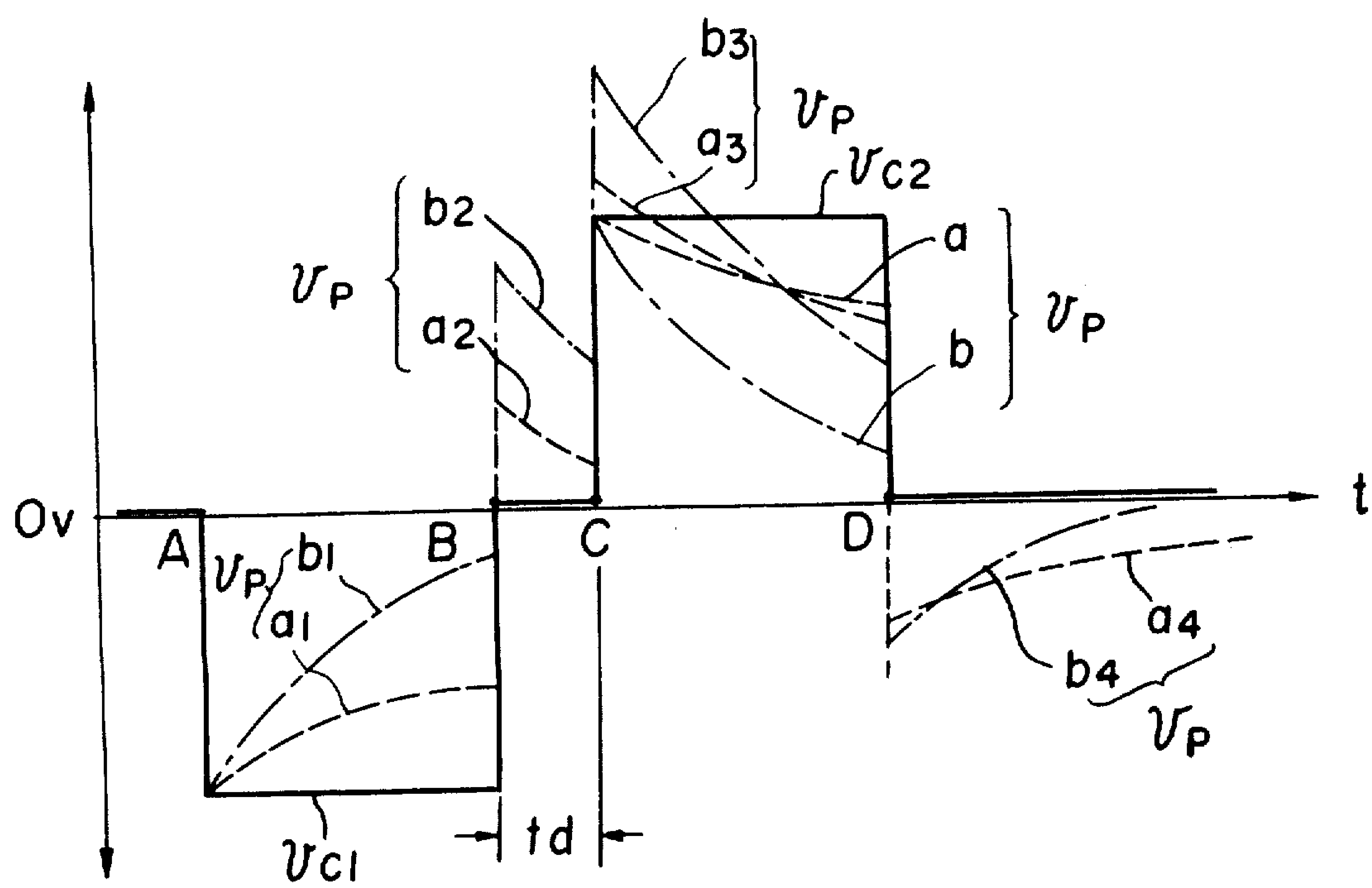
Primary Examiner—Glen R. Swann, III

[57] **ABSTRACT**

An electrographic imaging system for driving a single surface control electrostatic recording head has recording stylus electrodes arranged in groups with respective stylus electrodes of each group connected in parallel and control electrodes arranged adjacent respective groups of stylus electrodes so as to form electrostatic latent images on a dielectric layer of a record medium contacting the recording head. In the electrographic imaging system a first control pulse voltage is applied to selected control electrode adjacent a selected group of stylus electrodes; and then a second control pulse voltage having a different polarity is applied to the control electrode and simultaneously, a recording pulse voltage having the same polarity as the polarity of the first control pulse voltage is applied to the selected respective group of recording stylus electrodes.

6 Claims, 17 Drawing Figures



PRIOR ART

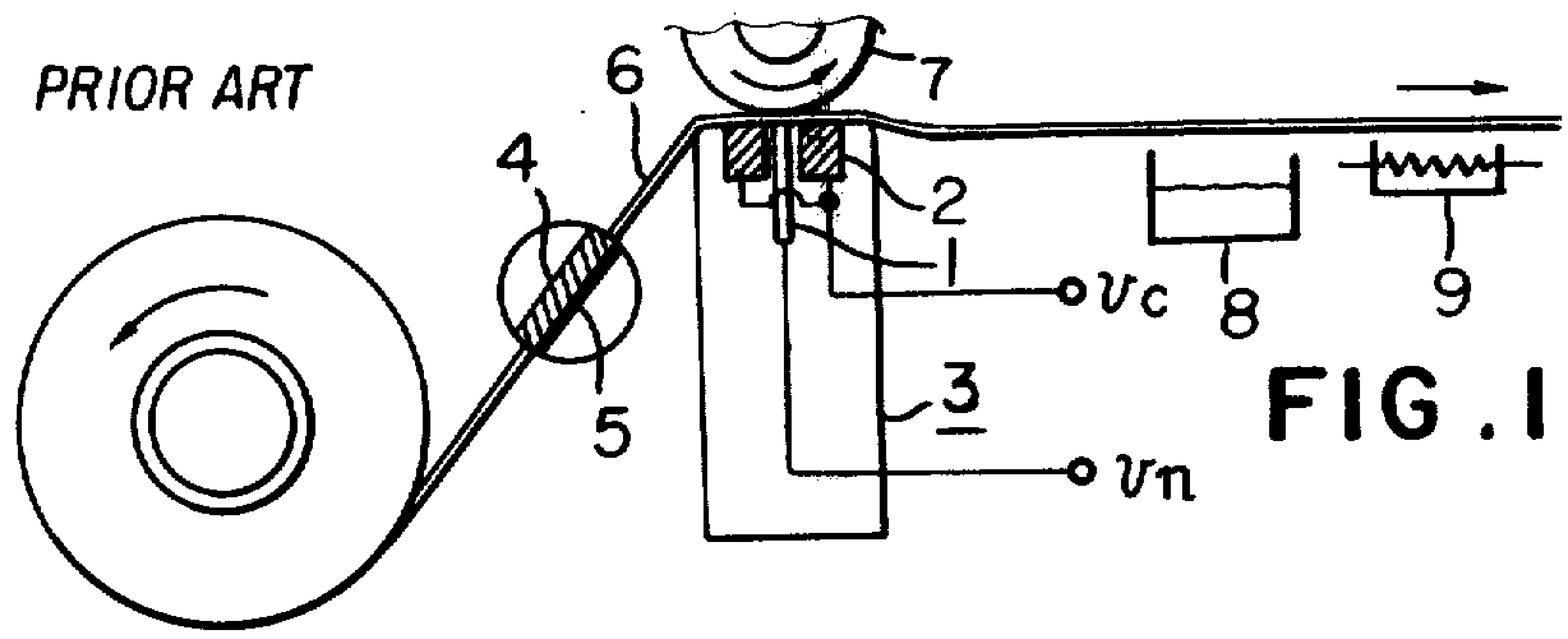


FIG. 1

FIG. 2
PRIOR ART

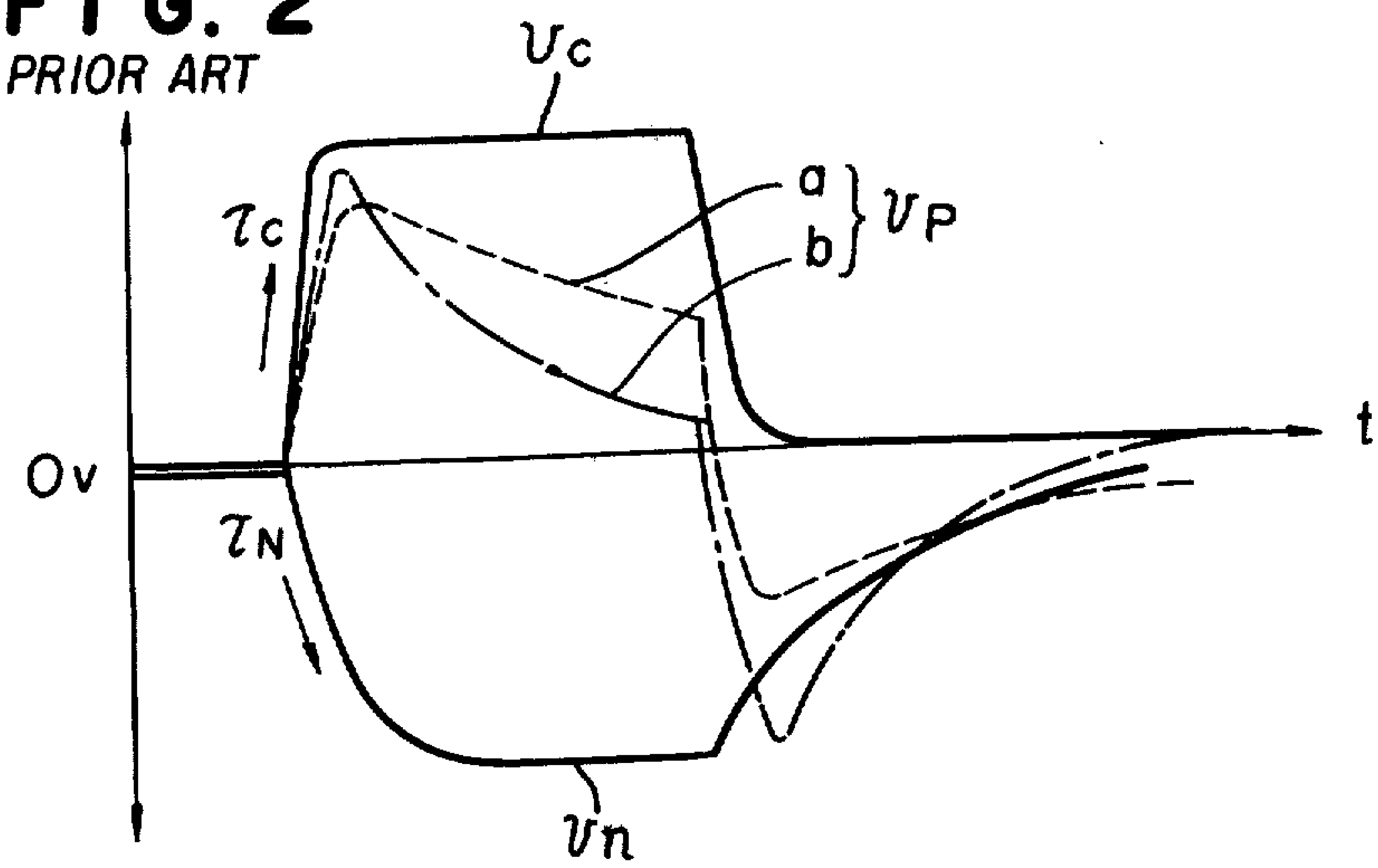
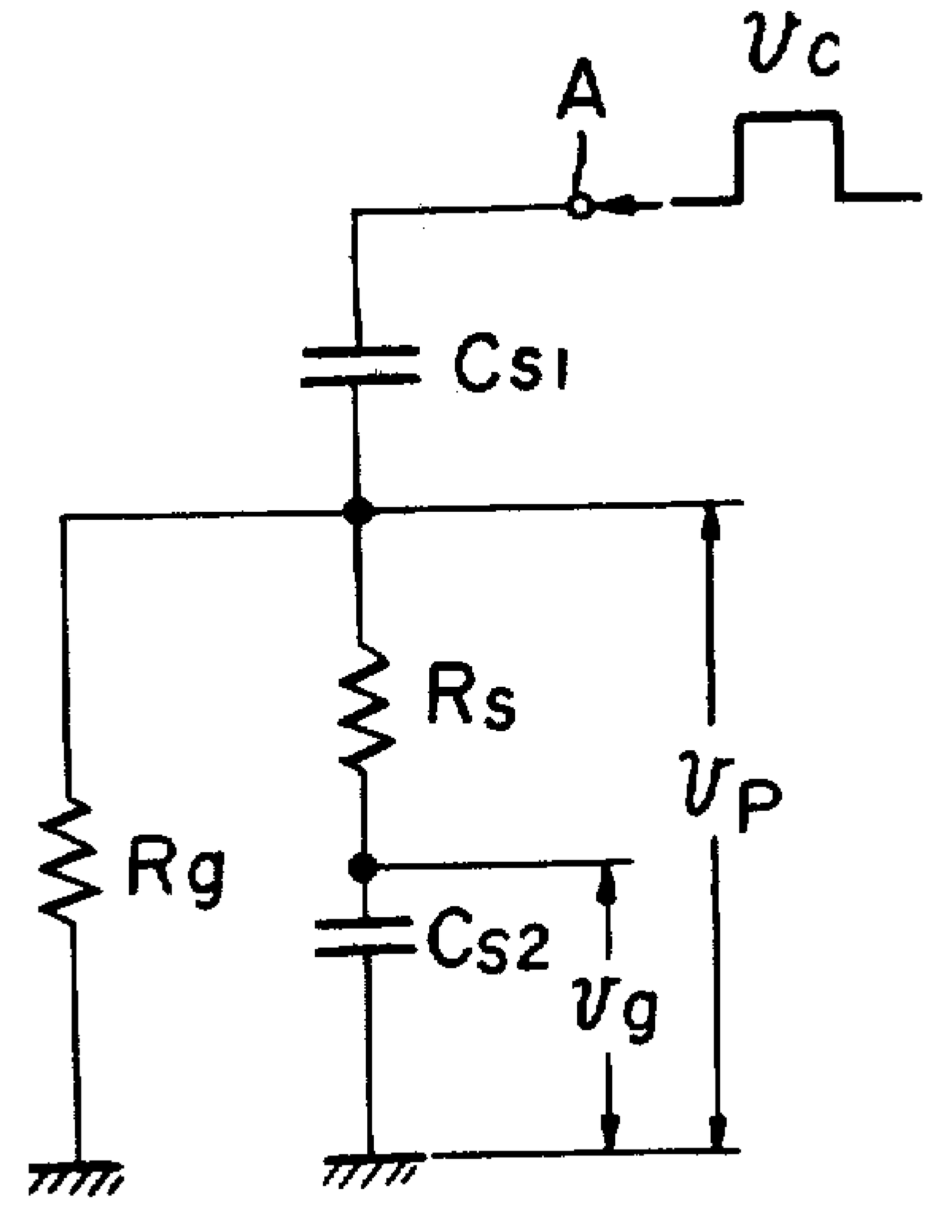
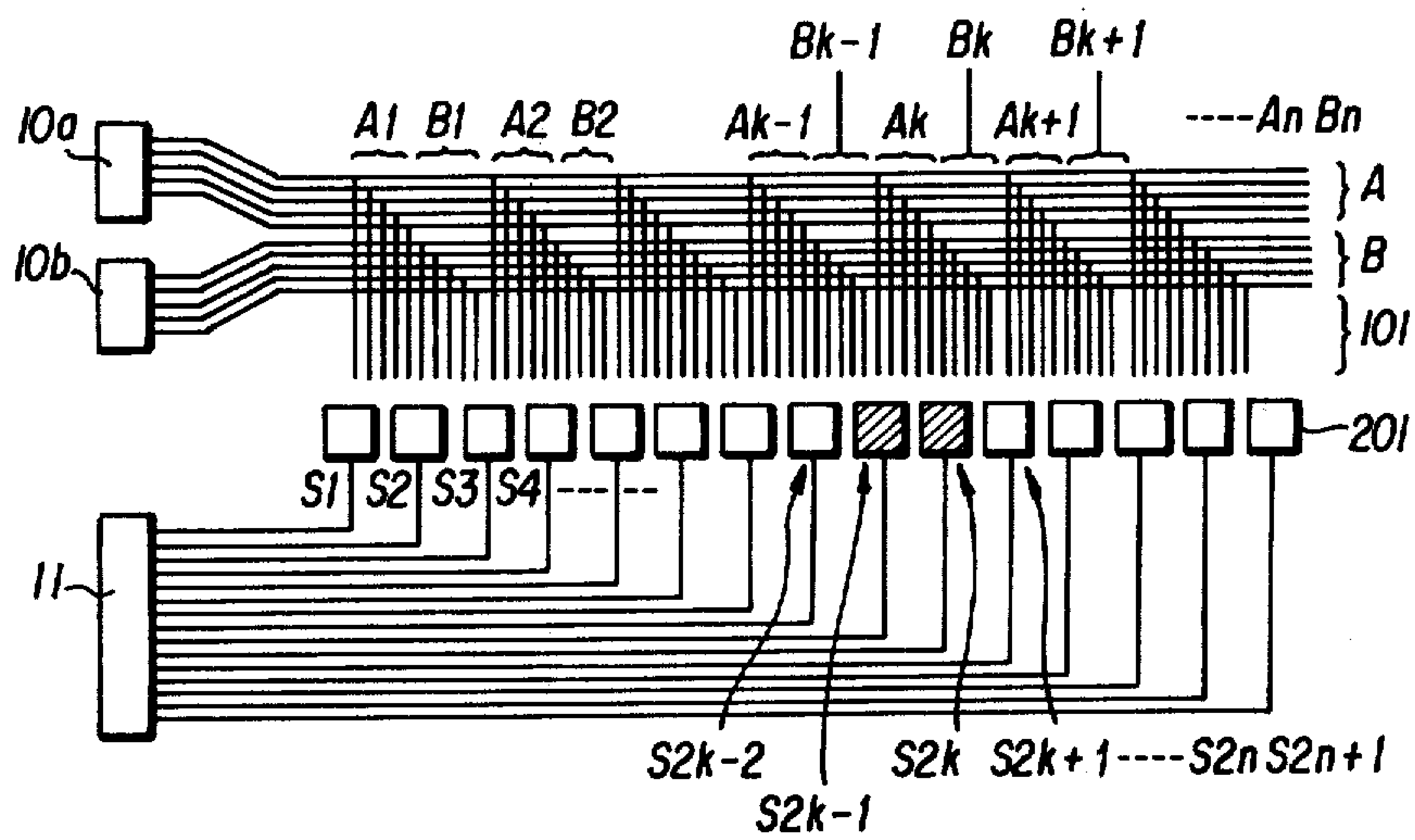


FIG. 3
PRIOR ART




Bk-1
Bk
Bk+1
A1
B1
A2
B2
Ak-1
Ak
Ak+1
----An Bn
10a
10b
A
B
101
201
S1
S2
S3
S4

11
S2k-2
S2k-1
S2k
S2k+1----S2n S2n+1

FIG. 4

FIG. 5
PRIOR ART

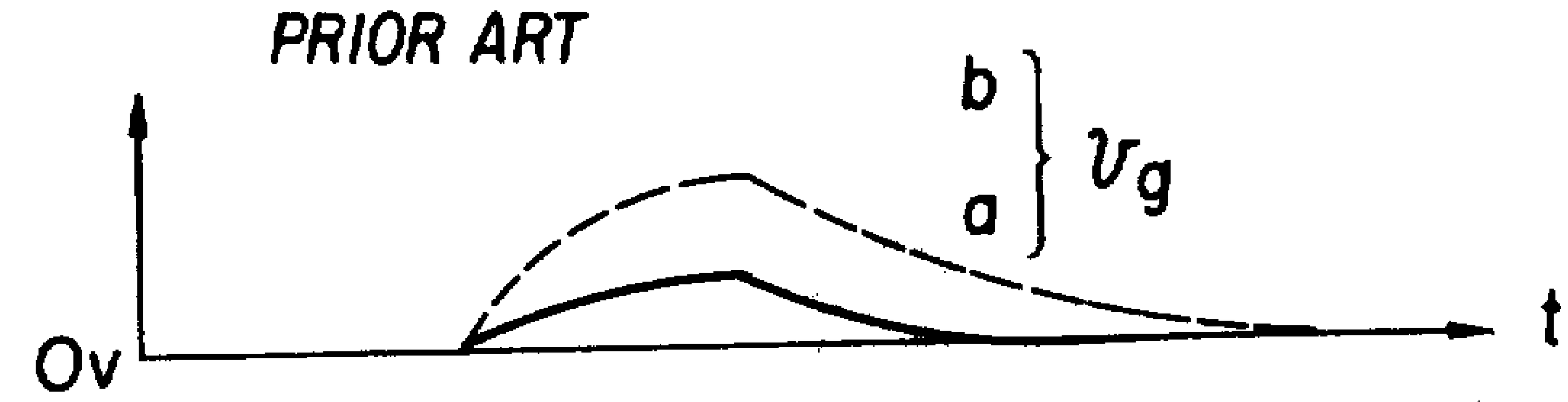


FIG. 6

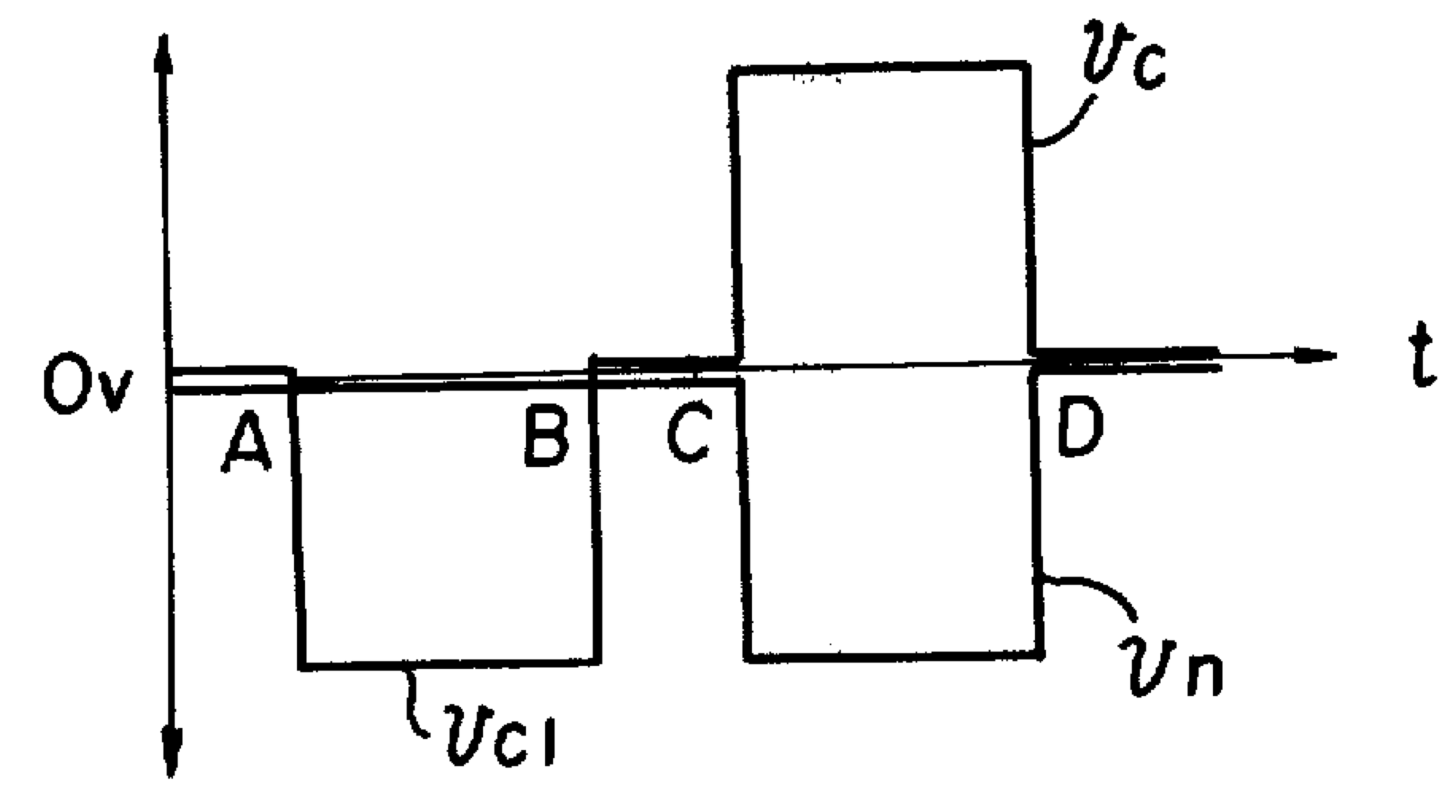


FIG. 7

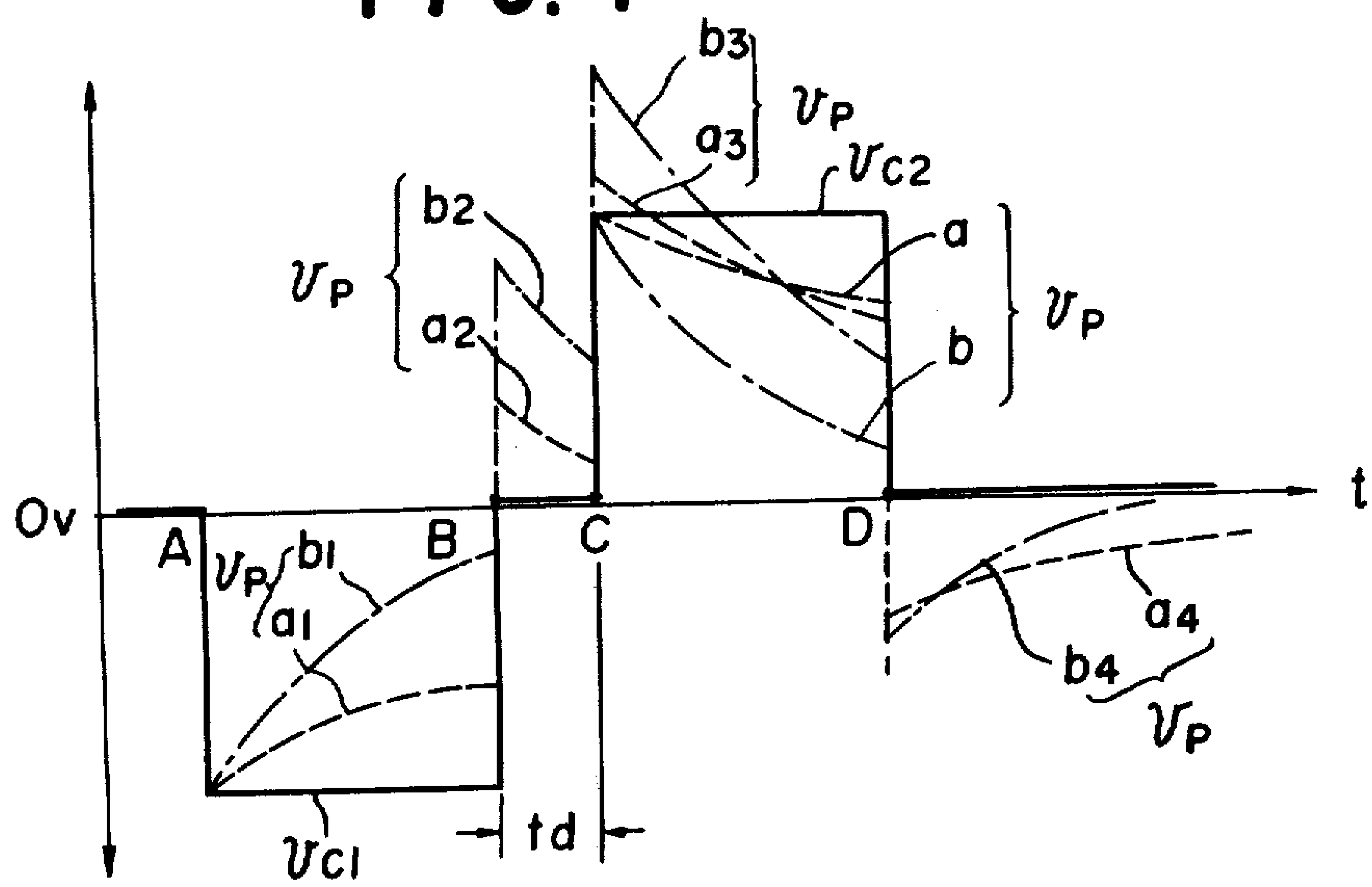
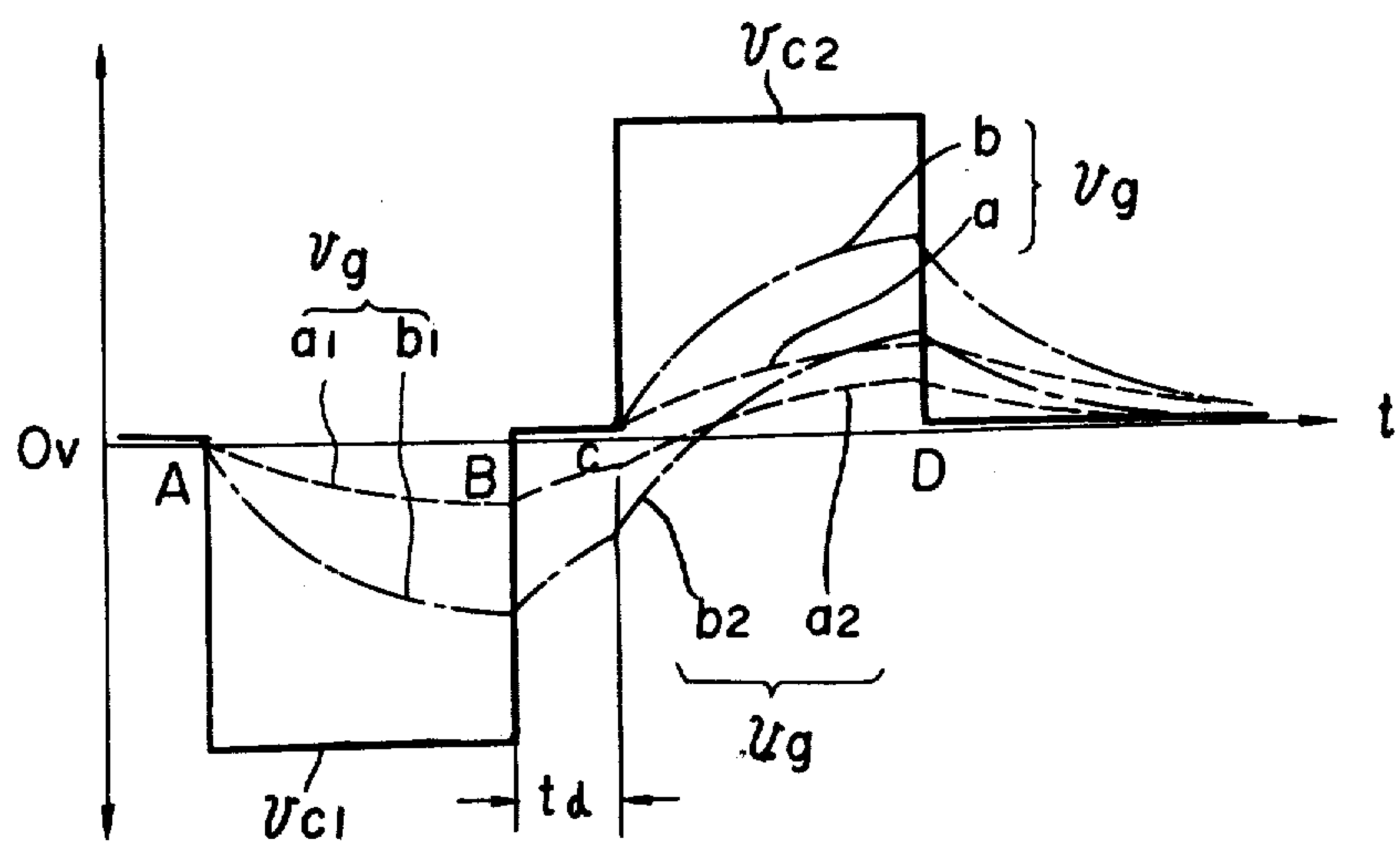
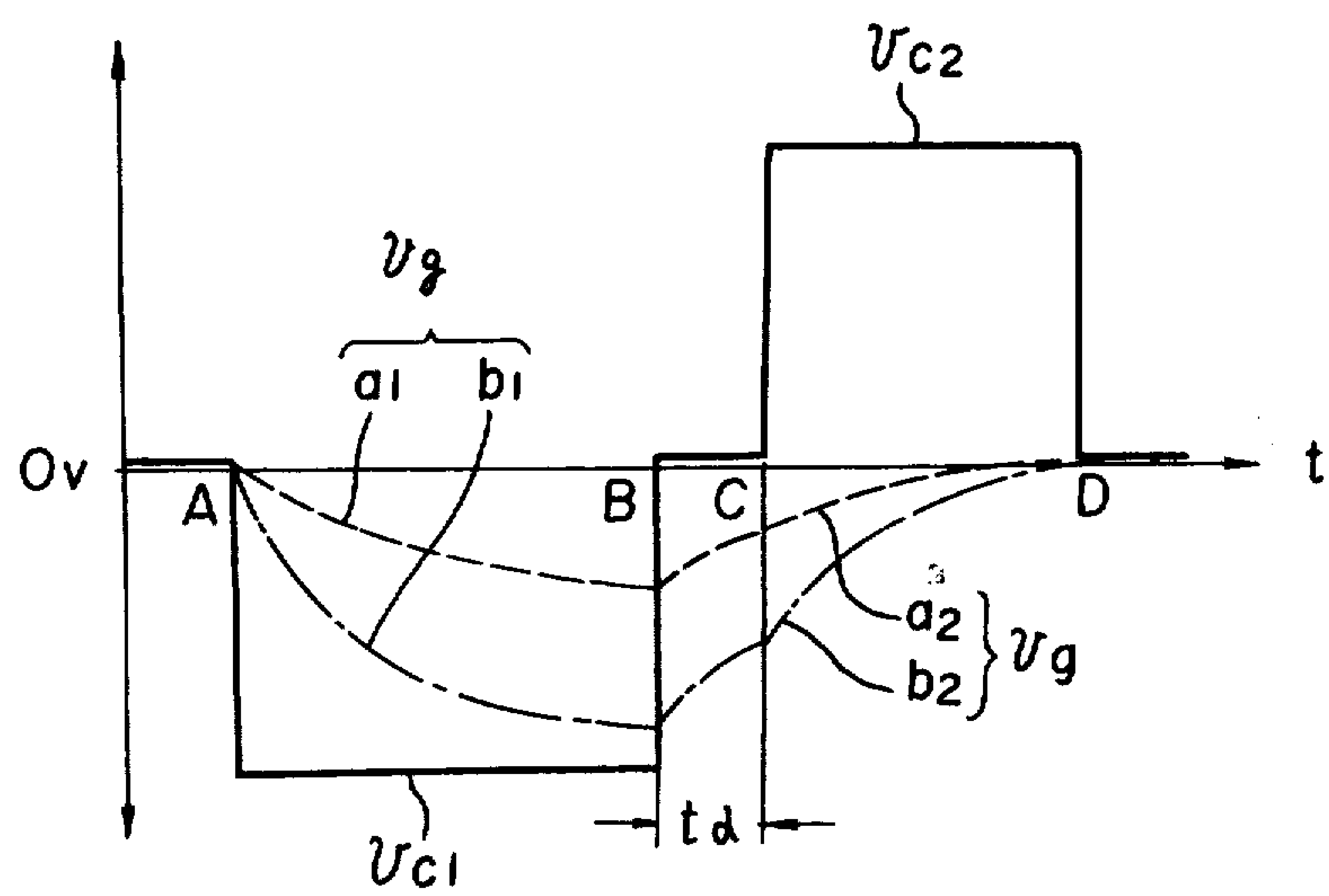


FIG. 8



Vc2
b
a
Vg
Vg
a1 b1
Ov
A
B
C
D
t
b2 a2
Vg
Vc1
td

FIG. 9



Vc2
Vg
a1 b1
Ov
A
B
C
D
t
a2
b2
Vg
Vc1
td

FIG. 10

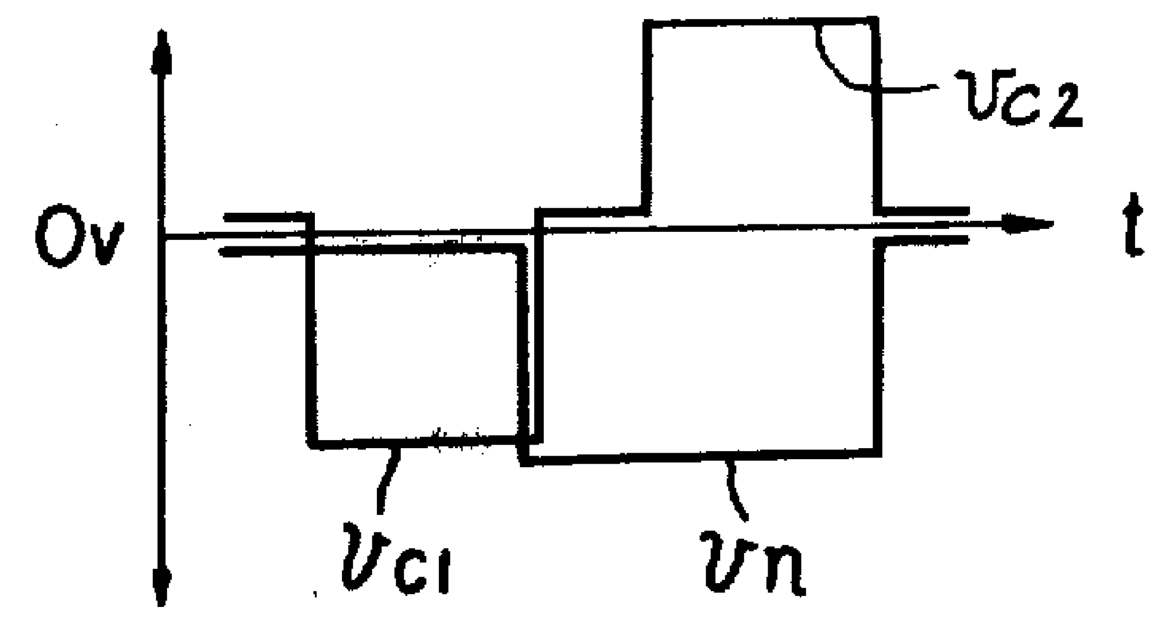


FIG. 11

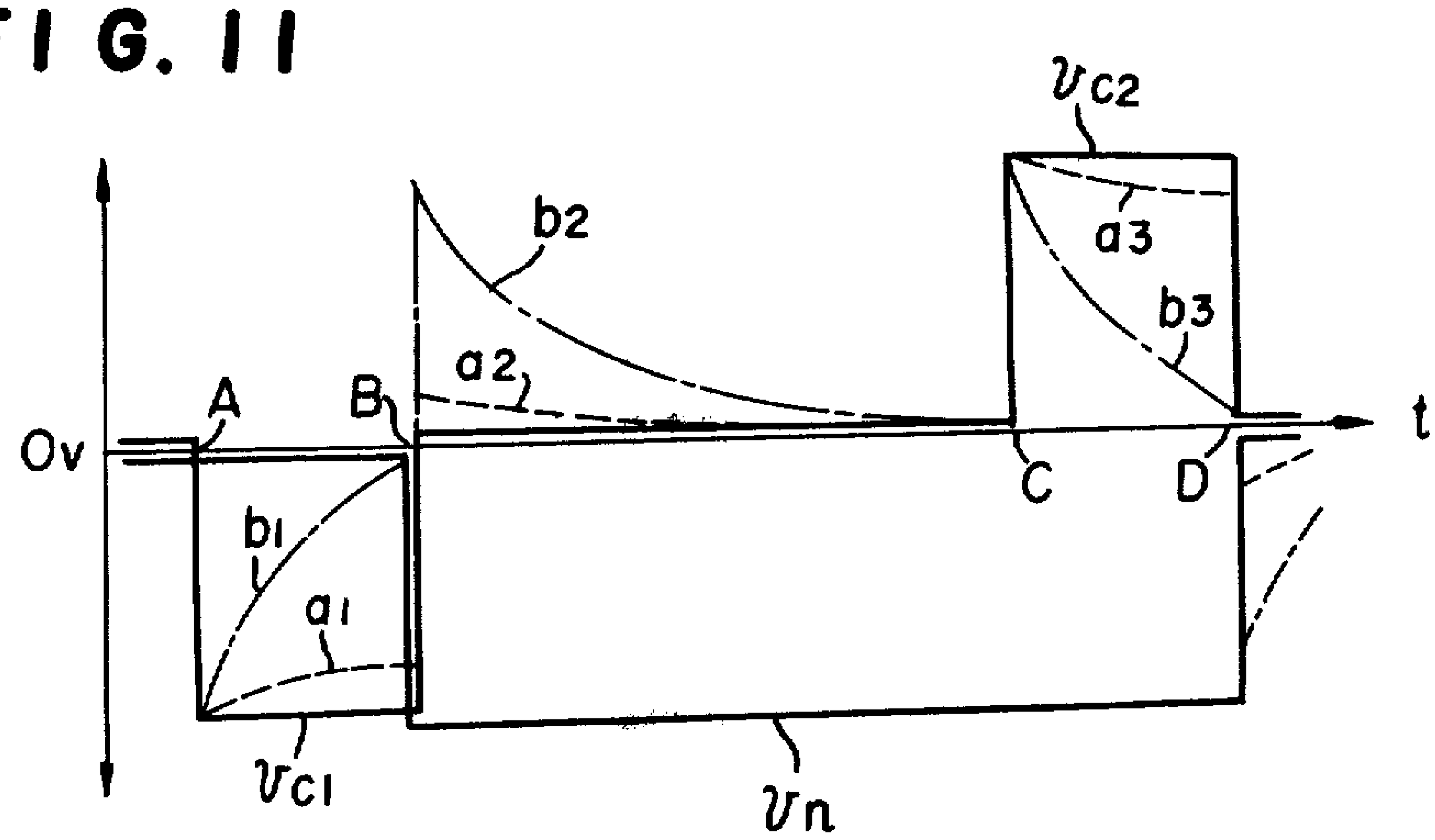


FIG. 12

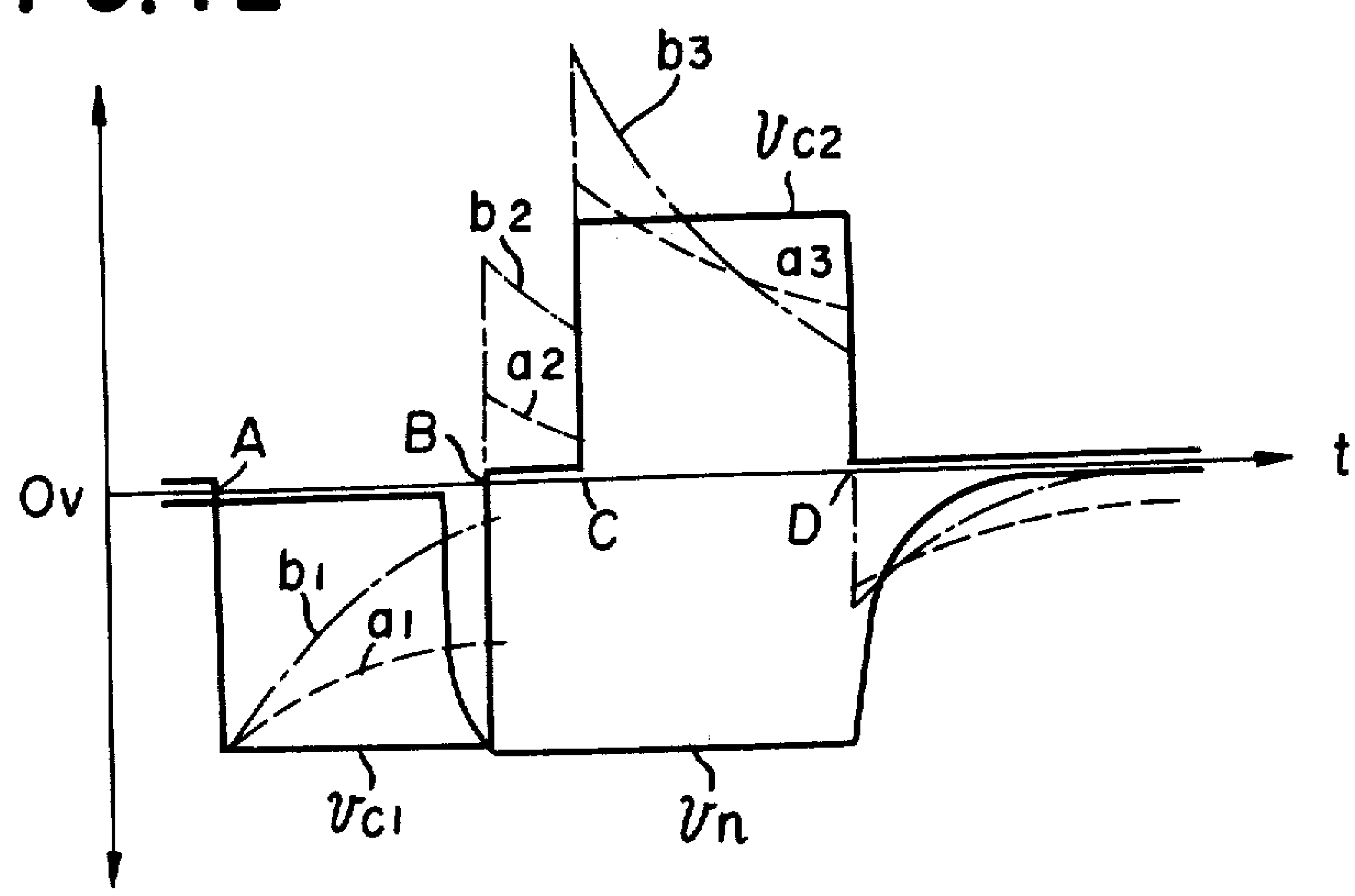


FIG. 13a

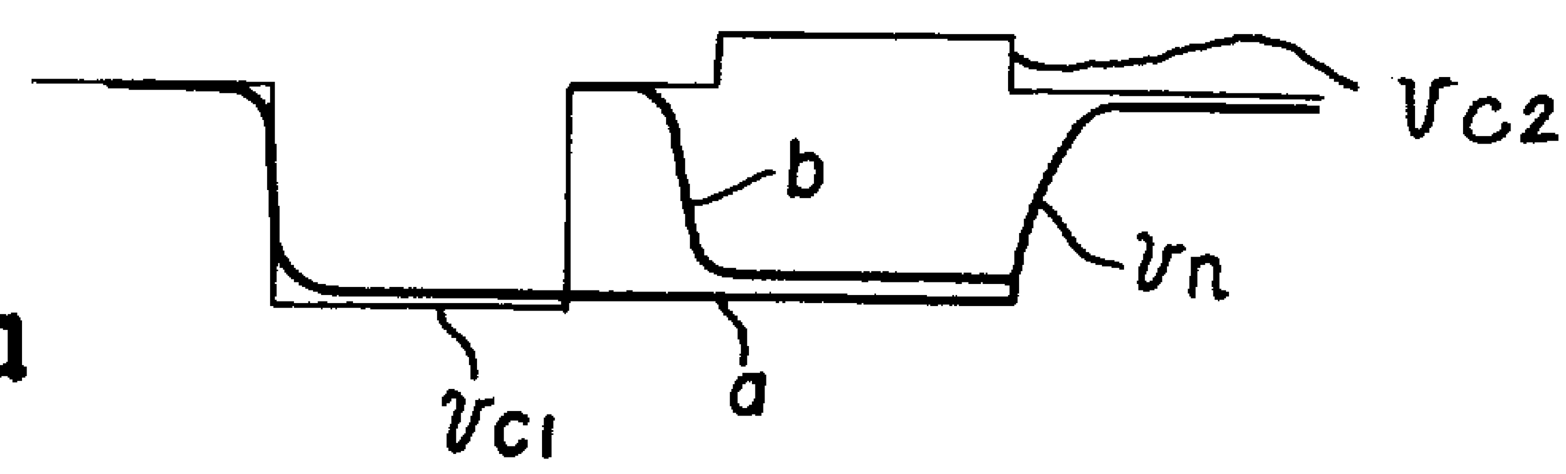


FIG. 13b

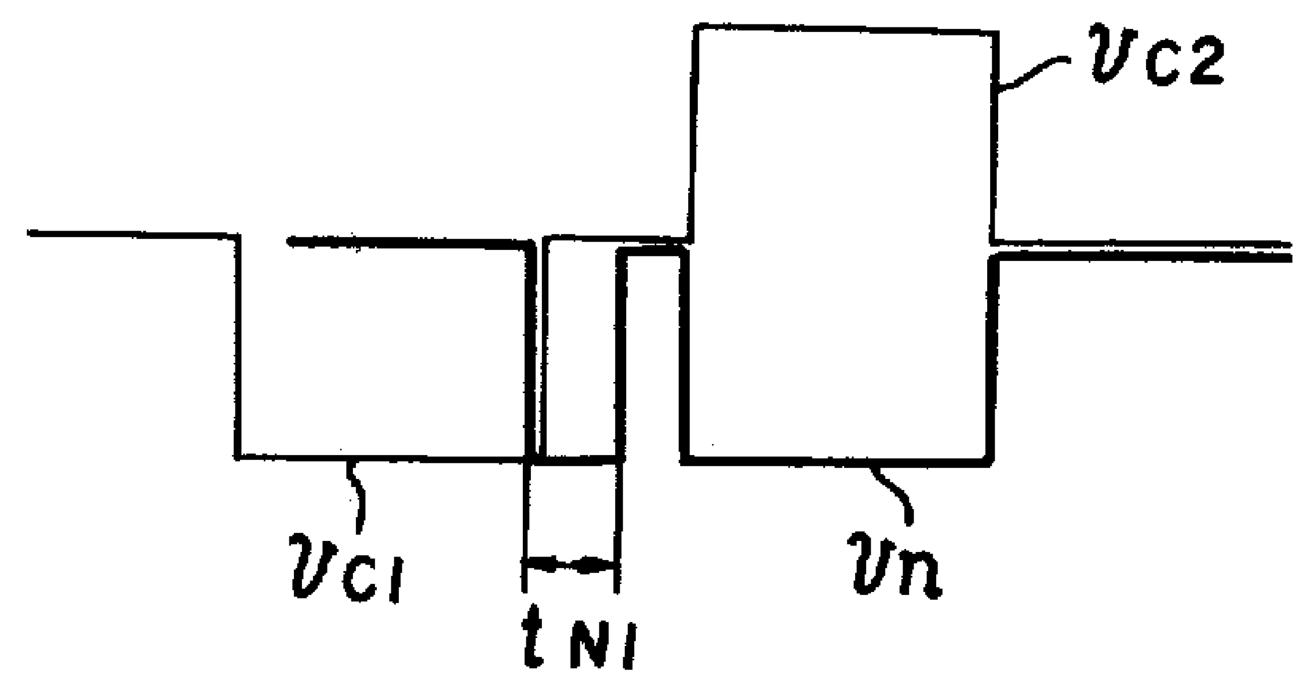


FIG. 13c

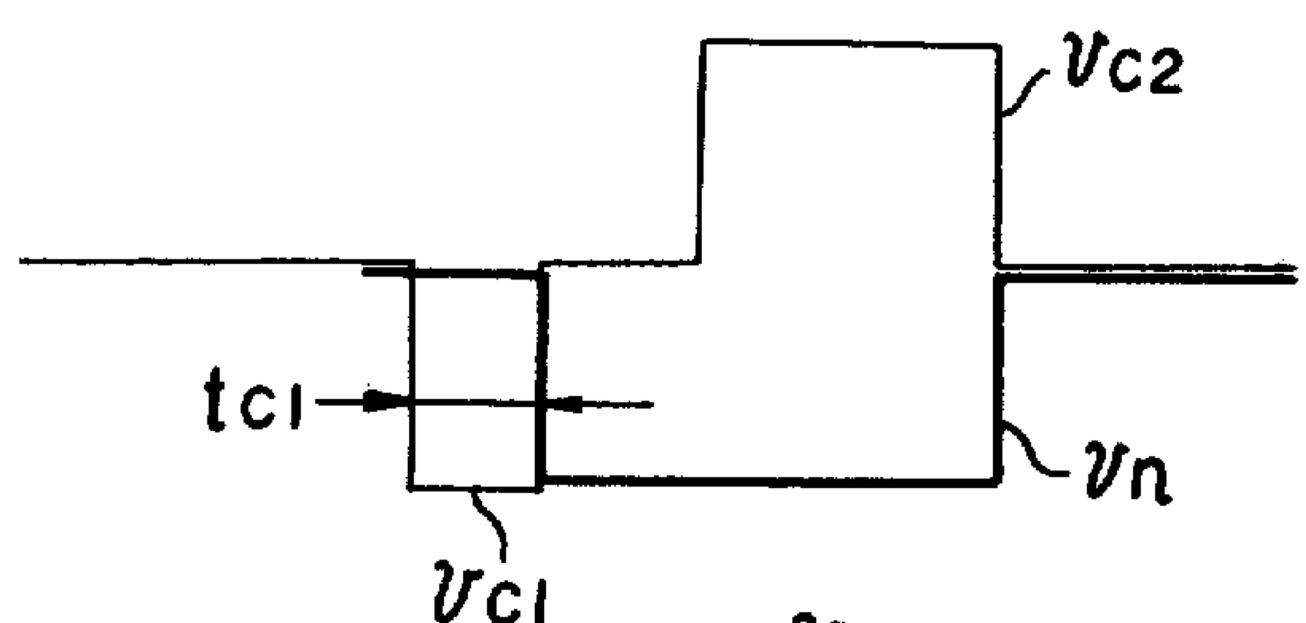


FIG. 13d

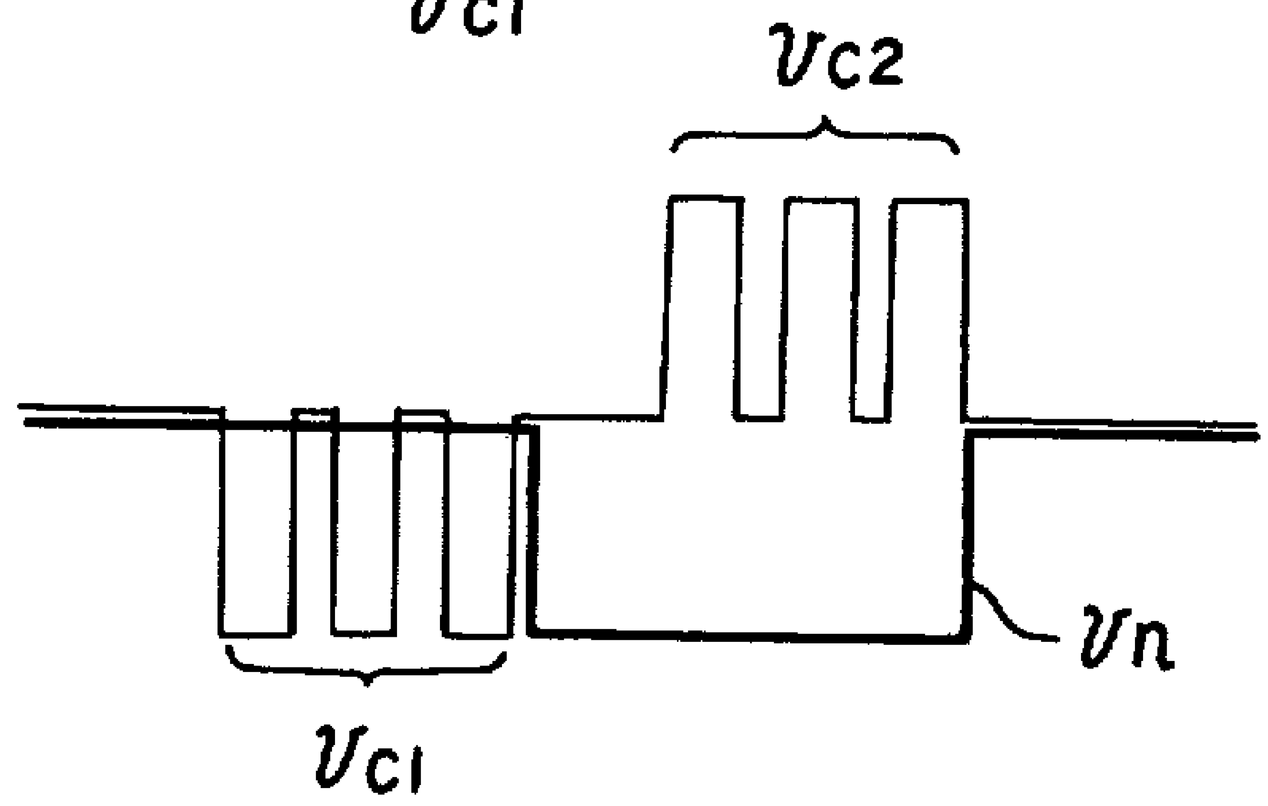
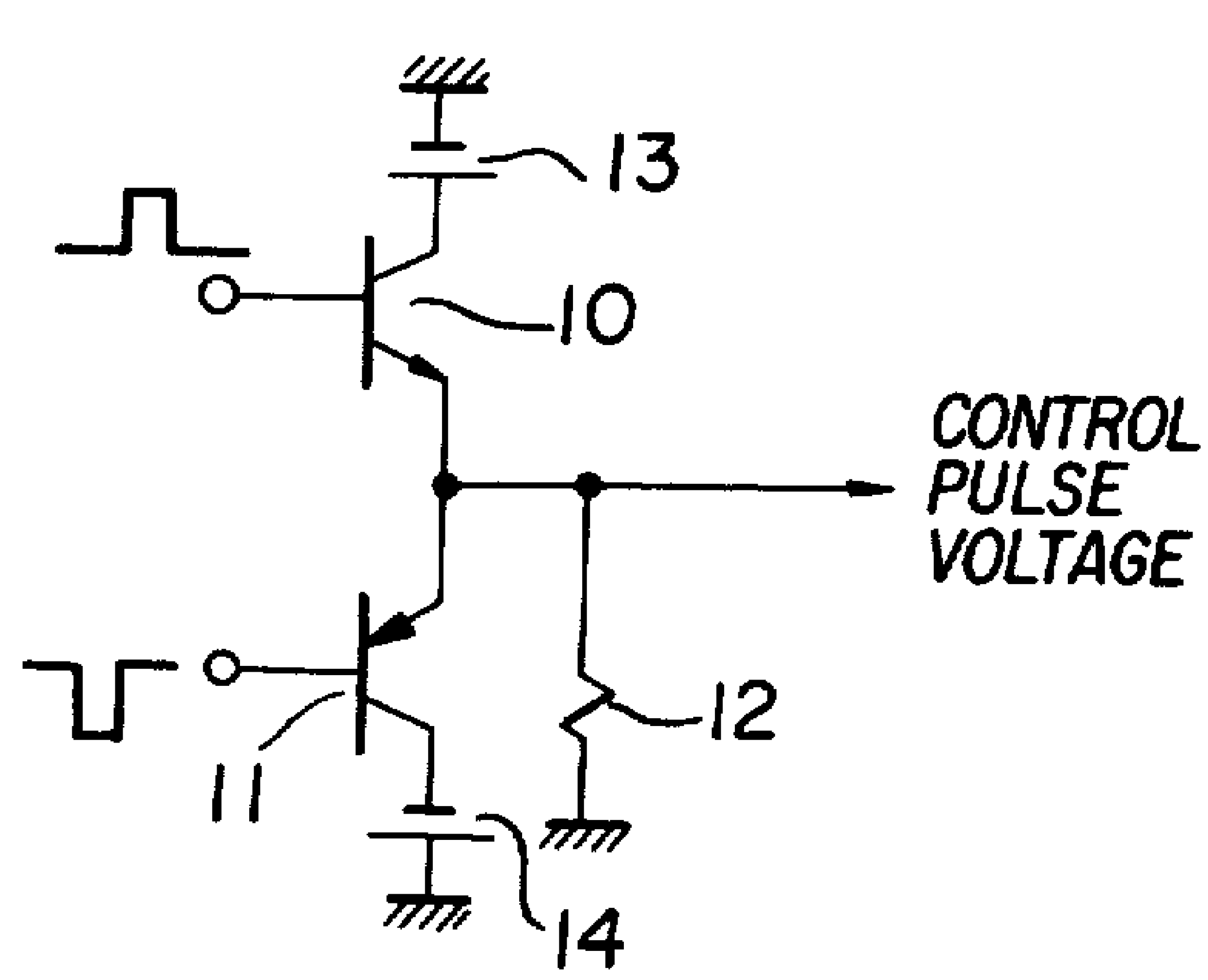


FIG. 14



ELECTROGRAPHIC IMAGING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrographic imaging system using an electrostatic recording head.

2. Description of the Prior Arts

FIG. 1 is a schematic view for showing a fundamental structure of a printing part in an electrographic imaging apparatus using a known single surface control electrostatic recording head (hereinafter referring to as a recording head). In FIG. 1, the reference numeral (1) designates recording stylus (only one stylus is shown) and many recording needles are orthogonally arranged to a paper. A plurality of groups of control electrodes (2) (only one group is shown) are arranged for each predetermined number of the recording styluses (1) at both sides of the recording styluses. An electrostatic record medium (6) made of a conductive substrate (4) and a dielectric layer (5) is press-contacted with a head surface of a recording head (3) having said structure.

Under such condition, a negative recording stylus voltage v_n is uaually applied to the recording stylus (1) and a positive control voltage v_c is simultaneously applied to the control electrode (2) whereby an electrostatic latent image is formed on the surface of the dielectric layer of the electrostatic record medium (6). The latent image formed on the electrostatic record medium (6) is developed in a toner development by a developing device (8) and the toner is melt-bonded by a heat-fixing device (9).

FIG. 2 shows waveforms v_n and v_c in the conventional electrographic imaging system; and v_p is a potential of the conductive medium (4) just below the control electrode (2) to which the control voltage v_c is applied.

FIG. 3 is an approximate equivalent circuit for the electrostatic record medium to which the control voltage v_c is applied; and C_{s1} designates and electrostatic capacity of the dielectric layer (5) just below the control electrode (2) to which the control voltage v_c is applied; C_{s2} designates an electrostatic capacity of the dielectric layer (5) at the part contacted with the control electrode being adjacent to the control electrode to which the control voltage v_c is applied; R_g designates a resistance of the conductive medium (4) from the earth point to the control electrode to which the control voltage v_c is applied; R_s designates a resistance of the conductive medium (4) between said two control electrodes.

The potential v_p has the waveform shown by the curve a in FIG. 2. That is, a differential waveform of v_c having a time constant of

$$C_{s1} + \frac{R_g R_s}{(R_g + R_s)}$$

is substantially equal to the waveform of v_p.

The resistances R_g and R_s are remarkably decreased depending upon the elevation of the temperature or humidity. Accordingly, v_p is in peak value at the leading edge of the control voltage v_c and remarkably attenuates as shown by the curve b in FIG. 2 at high temperature and high humidity. The latent image is formed on the dielectric layer (5) by a voltage of the sum of absolute values of v_p and the recording stylus voltage v_n.

In the case of a many stylus electrode type recording, recording multi-styluses are grouped and arranged in parallel. Accordingly, an electrostatic capacity between the recording styluses is ranging from about 150 to 400 pF. Thus, the time constant τ_n at the leading edge of the recording stylus voltage v_n is longer than the time constant τ_c at the leading edge of the control voltage v_c. In the condition of high temperature and high humidity for characteristics shown in the curve b in FIG. 2, the potential v_p attenuates to be small before reaching v_n to the saturated value whereby the record density is remarkably decreased to cause defect of the recording to be disadvantageous.

The decrease of the record density at high temperature and in high humidity is the first disadvantage which can not be avoided in the conventional system.

Moreover, in the conventional system, a ghost image caused by a leakage of voltage to the adjacent control electrode is found as the second disadvantage.

FIG. 4 is a fundamental circuit diagram used in the conventional system. The reference numeral (101) designates recording multi-styluses electrodes which are linearly arranged; (201) designates control electrodes which are divided into units having predetermined electrodes and are arranged as groups at both sides of the recording styluses(101). In the embodiment, the control electrodes are divided into each unit for each five recording styluses (101).

The recording styluses(101) are connected to form alternately groups A and groups B for each five recording styluses so as to form a total 2n blocks.

In said structure, when the recording of the A_1 block is carried out, the recording stylus voltage v_n is applied from the group A recording signal source (10a) depending upon the predetermined recording pattern for A_1 and simultaneously, the control voltage v_c is applied from the control voltage source (11) to S_1 and S_2 of the control electrodes (201). The recording is carried out only in the block A_1 to which both of v_n and v_c are simultaneously applied.

When A_k is recorded, the control voltage v_c is applied to S_{2k-1} and S_{2k}. When B_k is recorded, the control voltage v_c is applied to S_{2k} and S_{2k+1}. The recording for one line is sequentially completed.

When the state applying the pulse voltage v_c to S_{2k-1} and S_{2k} is considered, the potential v_g of the electrostatic record medium just below the adjacent control electrodes S_{2k-2} and S_{2k+1}, is elevated to cause ghost voltage v_g because of the leakage of v_c as shown by the curves a and b in FIG. 5.

The curves a and b respectively correspond to v_g in the conditions of low humidity and high humidity. Thus, the reason why v_g is suddenly elevated in high humidity, is to decrease the resistance r_s of the conductive medium of the electrostatic record medium in the equivalent circuit shown in FIG. 3. The time constant for charging to the capacity C_{s2} from the adjacent control electrode is shortened so as to elevate v_g. Thus, the recording should be performed only in the block A_k, nevertheless, the recording is also performed in the block A_{k+1} and A_{k-1}. The excess recorded images are referred to as the ghost. The formation of the ghost is the second disadvantage in the conventional system.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electrographic imaging system in which said first and second disadvantages in the conventional system are overcome.

The present invention is to provide an electrographic imaging system wherein a control voltage v_c is made of a combination of a pair of positive and negative pulses and the control voltage v_c is applied for each one cycle in the predetermined polarity and the different polarity and the recording stylus voltage v_n having the different polarity is applied during at least the period applying the control voltage having the different polarity.

In the modification of the embodiment of the present invention, the control voltage v_c is applied for each one cycle in the predetermined polarity and the different polarity and the recording stylus voltage having the different polarity is applied during the period from the releasing of the control voltage having the predetermined polarity to the releasing of the control voltage having the different polarity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a fundamental structure of a printing part of an electrographic imaging apparatus using a single surface control electrostatic recording head;

FIG. **2** is a diagram of waveforms showing the relation of recording stylus voltages v_n and control voltages v_c in the conventional electrographic imaging system;

FIG. **3** is an approximate equivalent circuit of the control electrode part;

FIG. **4** is a circuit diagram for the fundamental structure used in the conventional system;

FIG. **5** is a diagram of waveforms of ghost voltages found in the conventional system;

FIG. **6** is a diagram of waveforms showing the relation of v_n and v_c in one embodiment of the present invention;

FIG. **7** is a diagram for illustrating variation of the potential v_p of an electrostatic record medium in the embodiment of FIG. **6**;

FIG. **8** is a diagram of waveforms of ghost voltage v_g in the embodiment shown in FIG. **6**;

FIG. **9** is a diagram of waveforms of v_{c1}, v_{c2} and v_g in the other embodiment of the present invention;

FIG. **10** is a diagram showing patterns of the control voltages and the recording stylus voltages in the other embodiment of the present invention;

FIG. **11** is a diagram of waveforms for illustrating the variation of the potential v_p of the conductive medium of the electrostatic record medium in the embodiment of FIG. **10**;

FIGS. **12** and **13** *(a)*-*(d)* respectively diagrams of waveforms of the other embodiment; and

FIG. **14** is a circuit diagram of a control voltage applying circuit used in the system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **6** shows the typical relation of the control voltage v_c and the recording stylus voltage v_n. The characteristic of the system is to combine a pair of positive and negative pulses for the control voltage v_c.

The first control voltage v_{c1} which has the same polarity with that of v_n is applied and then the second control pulse voltage v_{c2} (positive in this case) which has the different polarity to that of v_n is applied and v_n is applied during the period overlapping the second pulse (simultaneous application in this case). The two disadvantages in the conventional system can be overcome by said feature.

FIG. 7 shows the variation of the potential v_p of the conductive medium of the electrostatic record medium in order to illustrate the effect for preventing the decrease of the record density in the condition of high humidity. The curves a and b respectively show time variations of v_p in low humidity and high humidity.

When the first control pulse voltage v_{c1} having negative polarity is applied at A and it is turned off at B, the potential v_p is slowly attenuated in low humidity and it is remarkably attenuated in high humidity as shown by the curves a_1 and b_1 between A and B.

As it is clearly understood by the equivalent circuit shown in FIG. **3**, when the v_{c1} is turned off and the control voltage feeding terminal A is earthed, v_p turnovers to the positive polarity side for the voltage charging the capacity C_{s1} of the dielectric layer of the electrostatic record medium just below the control electrode to which v_{c1} is applied. The condition is shown by the curve between B and C in FIG. **7**. The values of the turnover voltages a_2, b_2 are higher at the side of higher attenuation of v_p in high humidity. The present invention is to consider the feature that the turnover voltage in high humidity is greater, so as to prevent the decrease of the record density. The second control voltage pulse v_{c2} having the different polarity to that of v_{c1} is applied just after the turn-off of v_{c1} or the time C delaying for t_d from the turn-off of v_{c1}, and it is turned off at the time D. Because of the application of v_{c2}, the voltage by v_{c2} is overlapped to the turnover voltage by v_{c1}, the potential v_p is higher than that of the application of only v_{c2}. The peak value of v_p is naturally increased in the higher humidity side as shown by the curves a_3 and b_3 between C and D.

The curves a and b in FIG. **7** respectively show waveforms of v_p in low humidity and in high humidity when v_{c1} is not applied in the case of FIG. **2**. As shown in the curve b, the attenuation of v_p is remarkably large in high humidity. In accordance with the system of the present invention, b_3 is higher than a_3 by the turnover voltage whereby the decrease of the record density can be prevented. Moreover, the record density is advantageously higher than those of the application of only v_{c2} in all environments because of the turnover voltage.

The voltage v_{c1} applied in the system of the present invention has the same polarity with that of the recording stylus voltage v_n whereby the recording is not caused and no trouble is caused by the application of v_{c1}.

FIG. **8** shows variation of the potential v_g of the conductive medium of the electrostatic record medium just below the adjacent control electrodes in order to illustrate the effect for eliminating ghost in the system of the present invention.

When the negative pulse voltage v_{c1} is applied, the potential v_g is elevated in the negative polarity side as shown in the curves a_1 and b_1 in the condition of low humidity and high humidity. Then, the pulse voltage v_{c2} is applied at C, the turnover of the potential v_g is started. Thus, the induction pulse voltages v_{c1} and v_{c2} are in the counter directions each other. The values a_2 and b_2 of the potential v_g having the same polarity with that of v_{c2} can be remarkably decreased.

The waveforms of v_g in the conventional system are given by the curves a and b in low humidity and in high humidity. The effect is clearly understood by the comparison of the curves a_2 and b_2.

In the system of the present invention, the delay time t_d for v_{c1} and v_{c2} is preferably shorter. Thus, the effect for decreasing ghost is found even though the delay time t_d is about several times of the pulse width of v_{c1} or v_{c2}.

FIG. **9** is a diagram illustrating the embodiment for completely eliminating v_g even though the delay time t_d is given.

When the pulse width of v_{c1} is longer than that of v_{c2}, the potential v_g after the v_{c2} pulse application can be decreased to about zero. The similar effect can be given by increasing a peak value of the pulse of v_{c1} over that of v_{c2}. On the other hand, the disadvantage of the conventional system can be overcome by decreasing the voltage of the pulse of v_{c1} or the pulse width of v_{c1} below that of v_{c2}.

Thus, in the system of the present invention, the waveform or the timing for application of the control voltage is not critical as far as v_{c1} and v_{c2} are respectively pulses having different polarity.

FIG. **10** is a diagram of one embodiment of a pattern of the control voltage and the recording stylus voltage in the other embodiment.

FIG. **11** is a diagram of waveforms for illustrating variation of the potential v_p in the voltage patterns shown in FIG. **10**. The period from the time B releasing the control voltage v_{c1} to the time C applying the control voltage v_{c2} is shown by a longer scale.

In FIG. **11**, the characteristic curve a shown by the dotted line shows the characteristic of variation of v_p in low humidity and the characteristic curve b shown by the dotted chain line shows the characteristic of variation of v_p in high humidity.

When the first control voltage pulse v_{c1} having negative polarity is applied at the time A, v_p slowly attenuates in low humidity as the characteristic curve a_1 whereas v_p remarkably attenuates in high humidity as the characteristic curve b_1. As it is clearly understood from the equivalent circuit shown in FIG. **3**, when the condition just after releasing the control voltage v_{c1} and earthing the point A, is considered, the potential v_p turnovers in the positive polarity side for the voltage charging the capacity C_{s1} of the dielectric layer of the electrostatic record medium just below the control electrode to which v_{c1} is applied. This condition is shown by the curves a_2 and b_2 between B and C in FIG. **11**.

The turnover voltage is higher in high humidity for remarkable attenuation of v_p than that of low humidity.

The present invention is to utilize said characteristics so as to prevent the decrease of the recording density in high humidity. That is, the recording stylus pulse voltage v_n is applied during the period of B to C in which the turnover voltage shown in FIG. **11** is resulted, and the recording is performed by the second control pulse voltage v_{c2} applied during the period C to D and the turnover voltage during the period B to C. The decrease of the record density is prevented by double recording in high humidity.

FIG. **12** is a diagram of characteristic of variation of v_p when the period B to C is short. When the period B to C is short, the second control pulse voltage v_{c2} is applied before the satisfactory attenuation of the turnover voltages by v_{c1} (curves a_2, b_2) during the period B to C. Accordingly, the voltages are overlapped during the period C to D for applying the second control pulse voltage v_{c2} and the peak value of v_p is elevated over the second control pulse voltage v_{c2} as shown by the curves a_3 and b_3. Thus, the peak value of v_p in high humidity for sudden potential attenuation is higher than that of low humidity and accordingly, the decrease of the record density can be completely prevented and moreover, the record density in high humidity can be increased over that of the normal humidity.

In the embodiment shown in FIG. **12**, the time applying the recording needle voltage v_n is gained for the leading time of v_n, from the time B, so as to completely utilize the turnover voltage during the period B to C. Thus, the recordings are synergically performed by the curves b_2 and b_3 in high humidity whereby the complete compensation in high humidity can be attained.

FIGS. **13** (*a*)-(*d*) are diagrams for modifications of the electrographic imaging system of the present invention.

FIG. **13**(*a*) shows the modification of the timing for applying v_n wherein v_n is applied at the same time applying v_{c1} in the case a and v_n is applied at the time gaining from the time applying v_{c2}. Thus, the timing for applying v_n can be varied as far as earlier than the application of v_{c2}.

FIG. **13**(*B*) shows the modification of applying the divided recording needle voltage v_n. The record density can be controlled by controlling the pulse width t_{n1}. The recording stylus voltage is not limited to a single pulse.

FIG. **13**(*c*) shows the modification that the pulse width t_{c1} of v_{c1} is shorter than that of v_{c2}. The turnover voltage of v_{c1} can be controlled by t_{c1} and accordingly, the humidity depending of the record density can be controlled.

In the system of the present invention, the pulse width, the pulse voltage or the waveform is not critical as far as the different polarity of the control pulse voltages v_{c1} and v_{c2}.

FIG. **13**(*d*) shows the modification wherein the control pulse voltages v_{c1} and v_{v2} are respectively divided into three to apply them. The control pulse voltage can be divided for each desired pulse numeral.

The combination of the modifications (a), (b), (c) or (d) is also possible.

FIG. **14** is a circuit diagram for generating the control pulse voltages having different polarities. The reference numerals **(10)**, **(11)** respectively designate NPN and PNP transistors and **(12)** designates a load resistor; and **(13)**, **(14)** respectively designate positive and negative power sources.

In the description of the present invention, the embodiment of a simple electrostatic record medium having a dielectric layer and a conductive medium in two layer structure has been illustrated. Thus, in the system of the present invention, a multi-layer electrostatic record medium having two or three layers for high speed recording can be used to provide the characteristics of the present invention. The structure of the electrostatic record medium is not critical.

The system of the present invention can be applied for any control system for controlling the potential of the conductive layer by a control electrode through the dielectric layer regardless of the structure, the arrangement and the grouping of the recording styluses and the grouping or the dividing of the control electrodes.

In the system of the present invention, the record medium is not limited to the electrostatic record paper, but it can be an electrostatic medium having a base of a plastic film; and an electrostatic medium formed on a cylindrical drum for a single surface control etc. Various electrostatic record media can be used for the controlling system of the present invention.

As described above, in accordance with the system of the present invention, it is possible to completely eliminate ghost image and the decrease of the record density even in high humidity. Thus, the system can be used for various fields such as fascimiles and electrographic printers and imparts excellent characteristics of the stability of the record and the improvement of quality of images.

We claim:

1. In an electrographic imaging system for driving a single surface control electrostatic recording head having recording stylus electrodes arranged in groups with respective stylus electrodes of each group connected in parallel and control electrodes arranged adjacent respective groups of stylus electrodes so as to form electrostatic latent images on a dielectric layer of a record medium contacting said recording head, an improvement characterized in that a first control pulse voltage is applied to selected control electrodes adjacent a selected respective group of stylus electrodes; and then a second control pulse voltage having a different polarity is applied to said selected control electrodes and simultaneously, a recording pulse voltage having the same polarity as the polarity of the first control pulse voltage is applied to said selected respective group of stylus electrodes.

2. An electrographic imaging system according to claim 1 wherein the potential difference of the first control pulse voltage to the earth is greater than the potential difference of the second pulse voltage to the earth.

3. An electrographic imaging system according to claim 1 wherein the period for applying the first control pulse voltage is longer than the period for applying the second control pulse voltage.

4. In an electrographic imaging system for driving a single surface control electrostatic recording head having recording stylus electrodes arranged in groups with respective stylus electrodes of each group connected in parallel and control electrodes arranged adjacent respective groups of stylus electrodes so as to form electrostatic latent images on a dielectric layer of a record medium contacting said recording head, an improvement characterized in that a first control pulse voltage is applied to selected control electrodes adjacent a selected respective group of stylus electrodes and then a second control pulse voltage having a different polarity is applied to said selected control electrodes and a recording pulse voltage having the same polarity as the polarity of the first control pulse voltage is applied to said selected respective group of stylus electrodes during a period from a time of the releasing of the first control pulse voltage to a time of the releasing of the second control pulse voltage.

5. An electrographic imaging system according to claim 4 wherein the first and second control pulse voltages are respectively formed by voltages having plural pulse forms.

6. An electrographic imaging system according to claim 4 wherein the recording pulse voltage is formed by voltages having plural pulse forms.

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